The SMART Reactor

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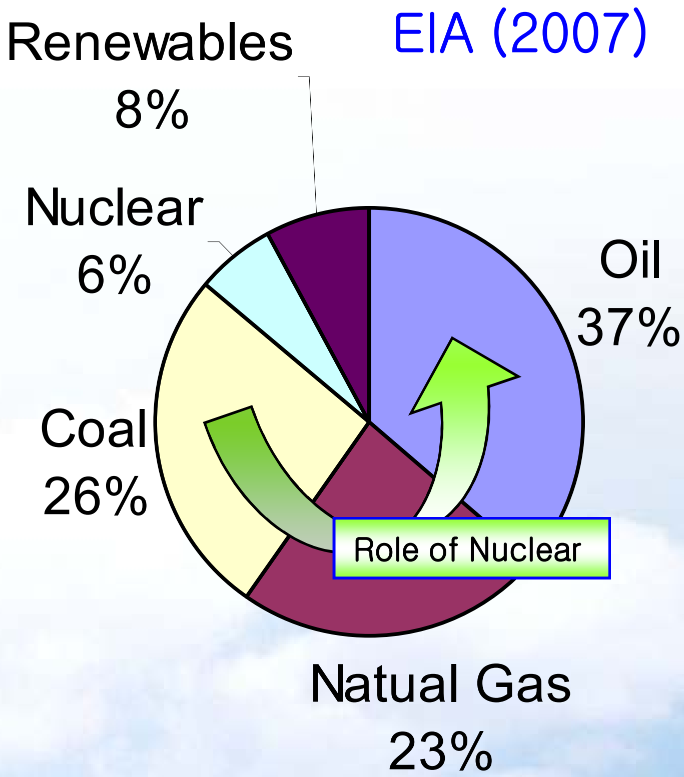
I. Introduction

❑ Nuclear, a Resolution to Energy, Water & Environment Issues

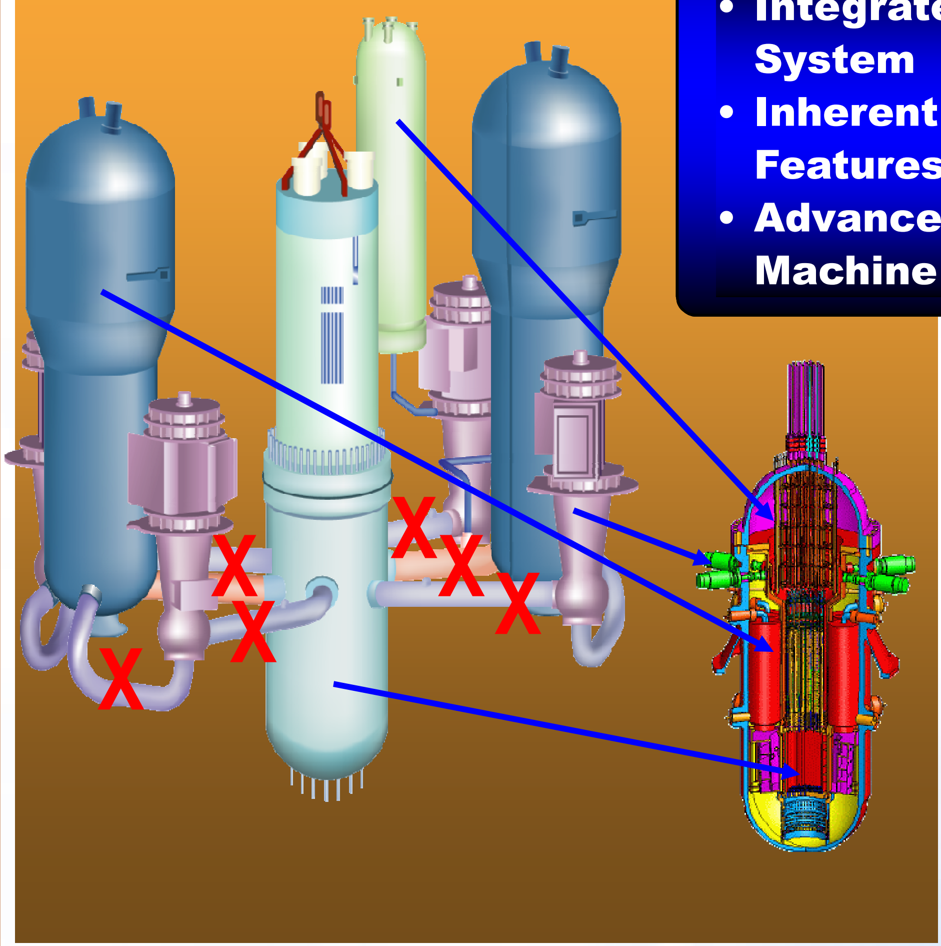
Richard Smalley ,
Energy & Nanotechnology Conference,
Rice University, Houston, May 3, 2003



- Small & Medium Reactors can provide Flexible Resolution to Energy, Water & Environmental Issues
  - Electricity to Countries with
    - Limited or Distributed Electricity Grid System
    - Limited Financial Resources for a Large Nuclear Power Plant
  - Combined Electricity and Process Heat to
    - Industrial Complexes: High Pressure Steam
    - Arid Regions: Water Desalination
    - Freezing Regions: District Heating
- SMART (System-integrated Modular Advanced ReacTor) is being developed by KAERI

II. SMART Design Features

Loop Type PWR

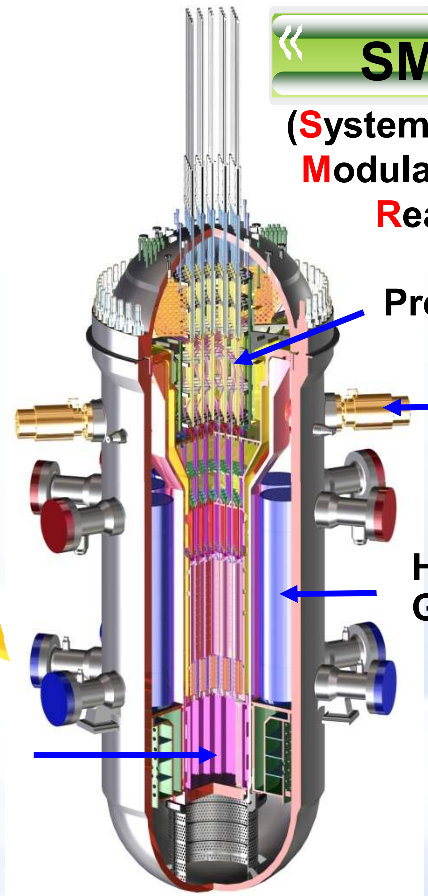


Innovative Design

- **Integrated Primary System**
- **Inherent Safety Features**
- **Advanced Digital Man-Machine Interface**

SMART

(**S**ystem-integrated **M**odular **A**dvance **R**eac**T**or)

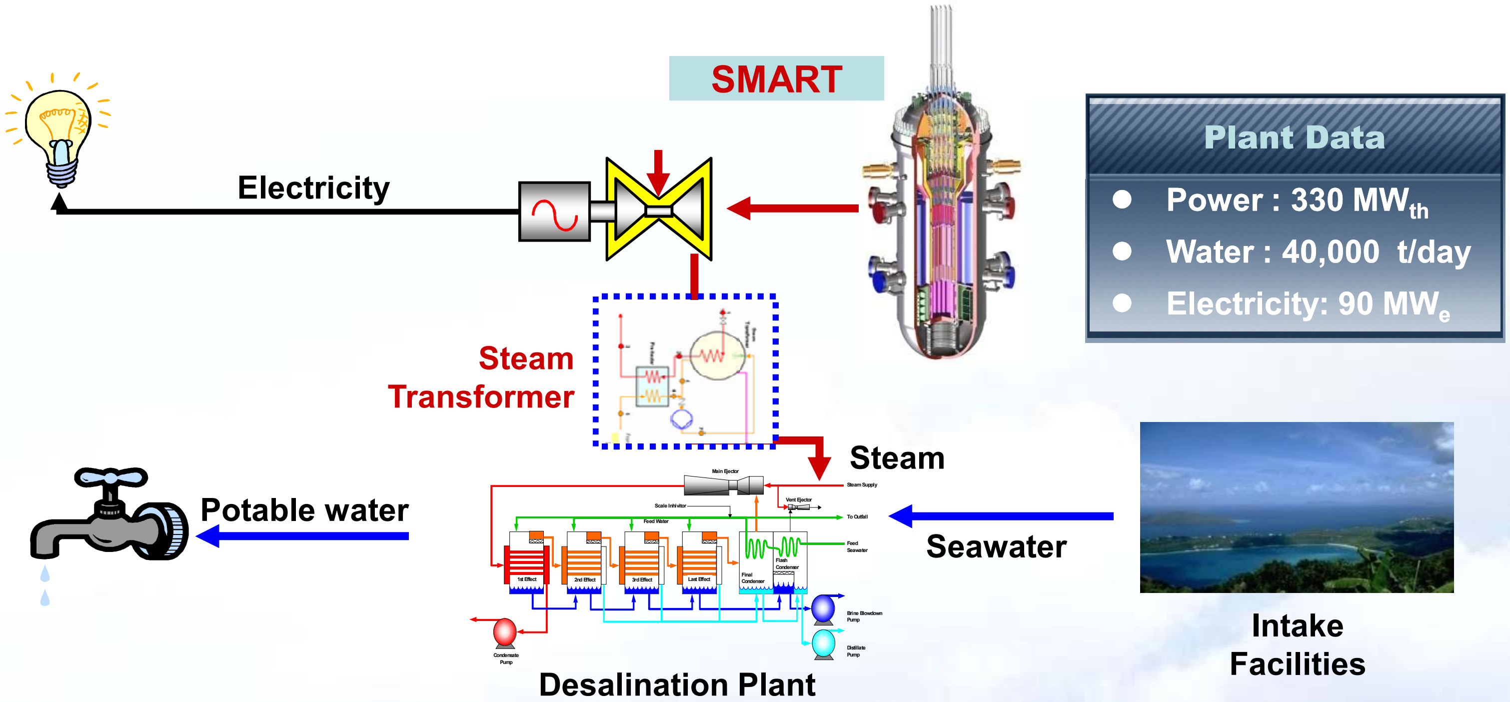


- Enhanced Reactor Safety: No LBLOCA
- Flexible Applications: Electricity, Heat
- Early Deployment: Proven Technology

SMART 330MW$_{th}$ Application

330MW$_{th}$ Integral PWR

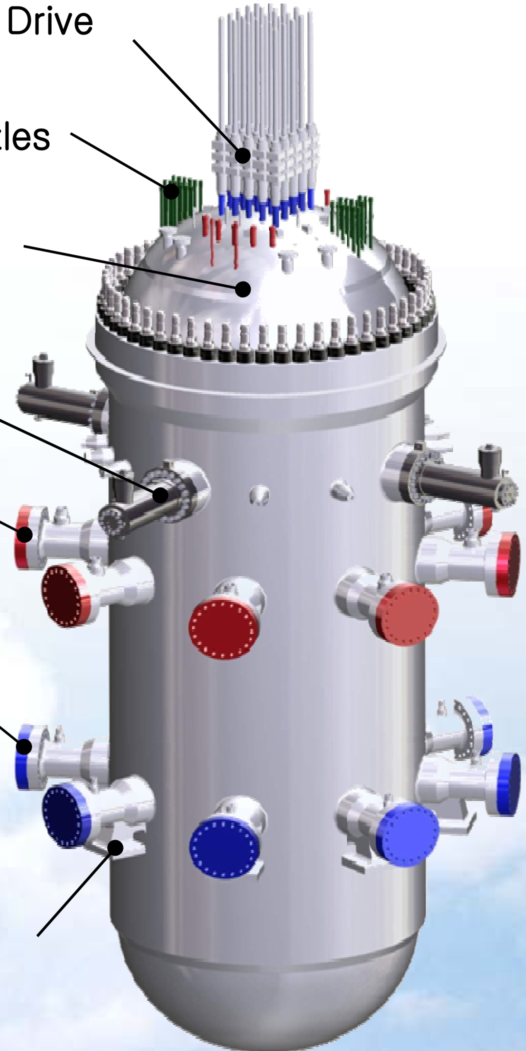
Electricity Generation, Desalination and/or District Heating



- Electricity and Fresh Water Supply to a City of 100,000 Population
- Suitable for Small Grid Size or Distributed Power System

NSSS - RPV

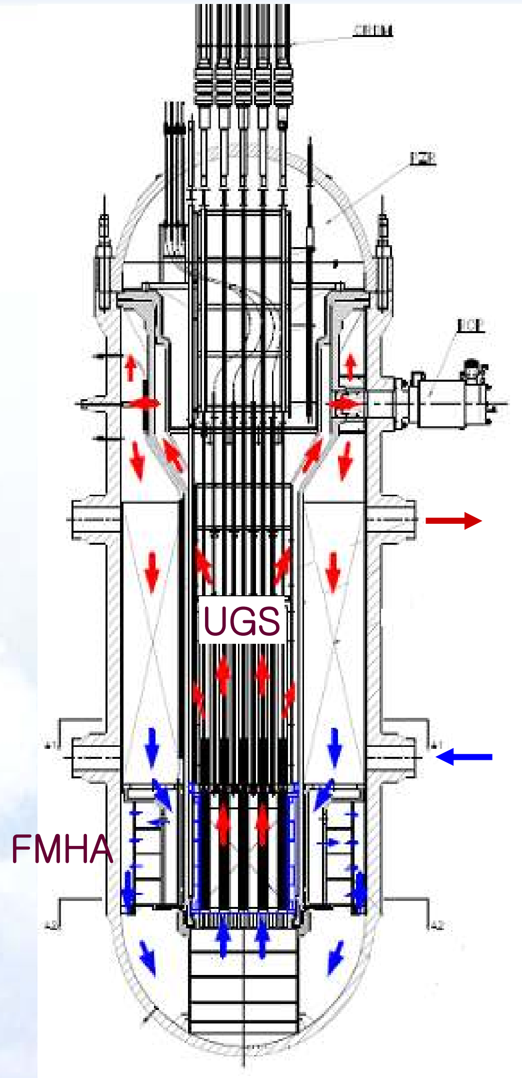
- **All Primary Components in a Reactor Pressure Vessel (RPV)**
  - 8 Helical Once-through SG's
  - 4 Canned Motor Pumps
  - Internal Steam Pressurizer
  - 25 Magnetic Jack type CRDM's
  - RPV Internals
    - Upper Guide Structure
    - Core Support Barrel
- **RPV**
  - 6.5m (D) X 18.5m (H)
  - Design Condition: 17MPa, 360°C
  - Reactor Life > 60 yrs



RPV Thermal-Hydraulics

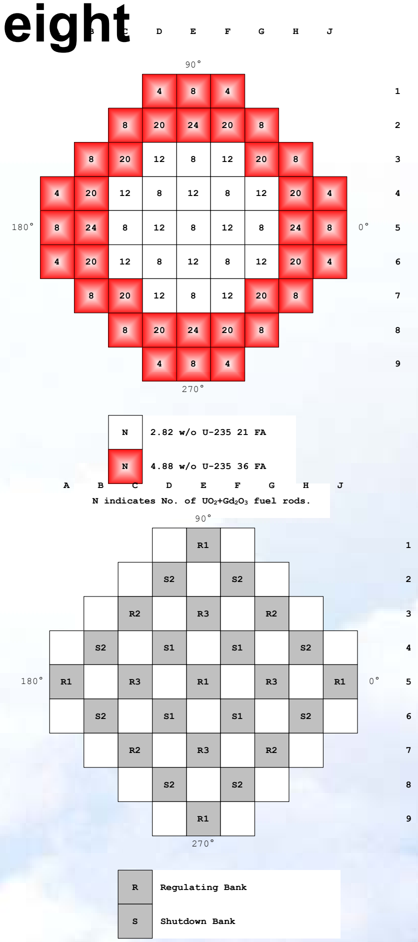
- Major Flow Path to Minimize Cross Flow in the Upper Guide Structure (UGS)
- Flow Mixing Header Assembly (FMHA) provides Thermal Mixing in case of TH Asymmetry
- Major TH Parameters

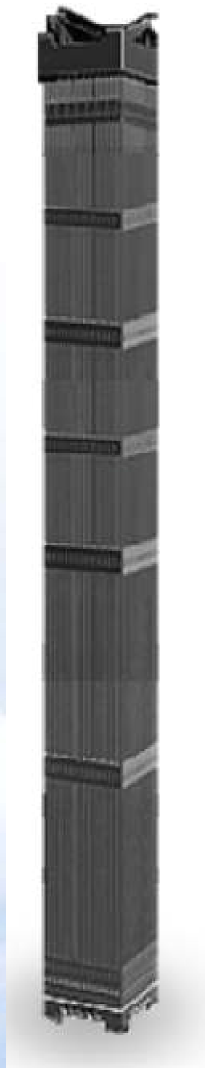
Parameter	Value
Pressure, MPa	15
Core Average Mass Flux, kg/m^{2}s	1361
Maximum Core Bypass, %	4.0
Average Rod Heat Flux, kW/m^2	360
Core Inlet Temperature, ^{o}C	295.7
SG Inlet, ^{o}C	323
Steam Superheating, ^{o}C	30
Fuel Thermal Margin, %	> 15



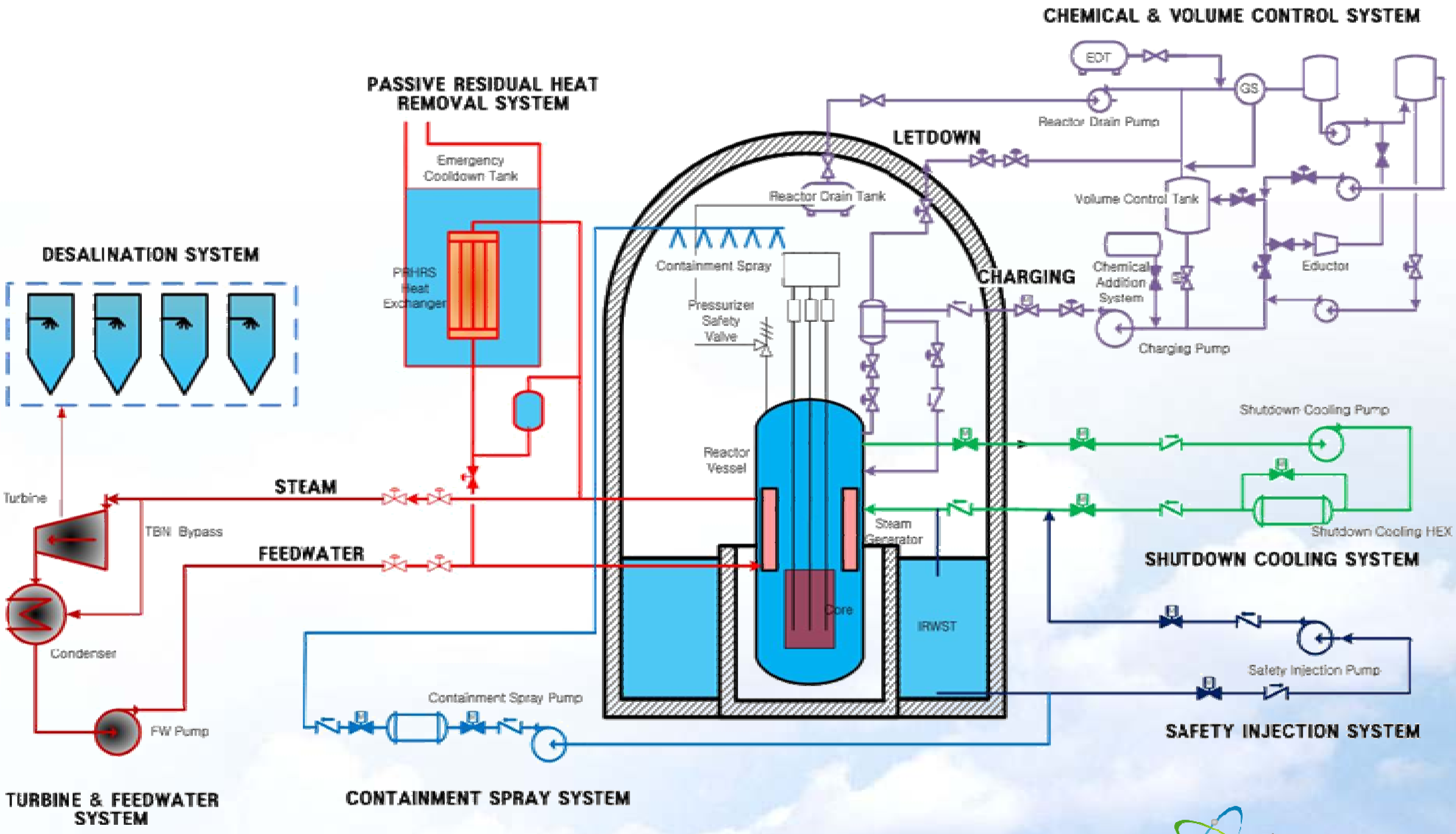
Fuel & Core

- **Fuel**
  - **Proven 17 x 17 LEU Fuel with Reduced Height**
  - **Peak Rod Burn-up > 60GWD/MTU**
- **Core**
  - **57 Fuel Assemblies**
  - **Fuel Cycle Length > 3 yrs**
  - **Availability Factor > 95%**
- **Proven Reactivity Control**
  - **External CRDM**
  - **Soluble Boron**
  - **Burnable Poison**
- **60 yrs of On-site Spent Fuel Storage**





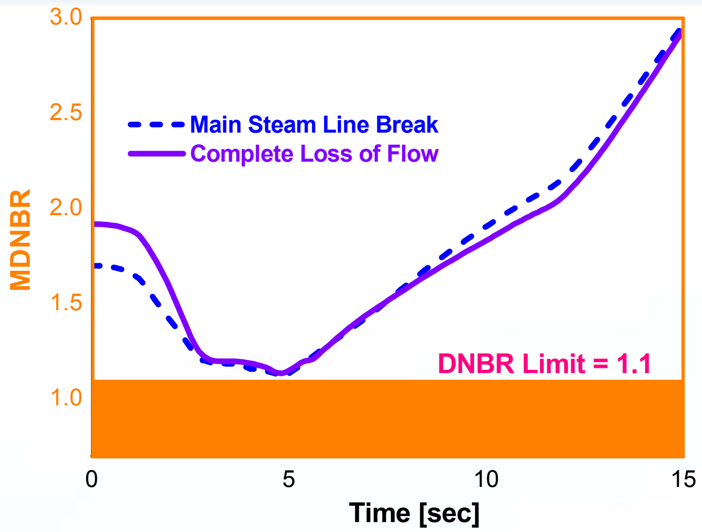
Fluid Systems

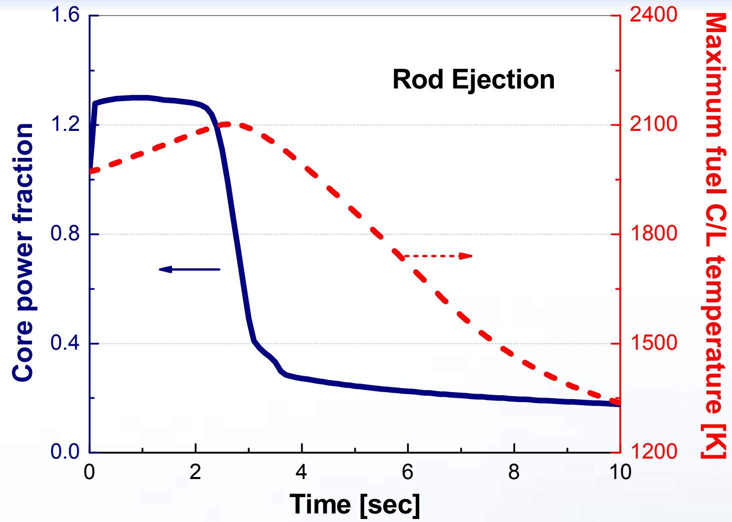


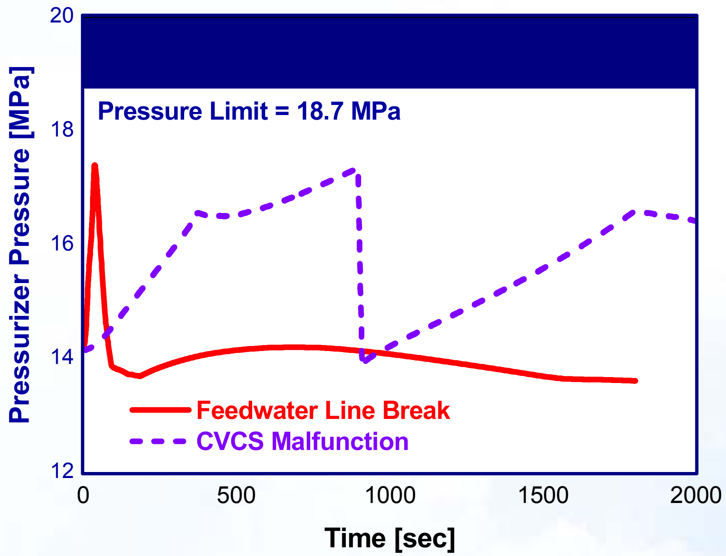
Safety

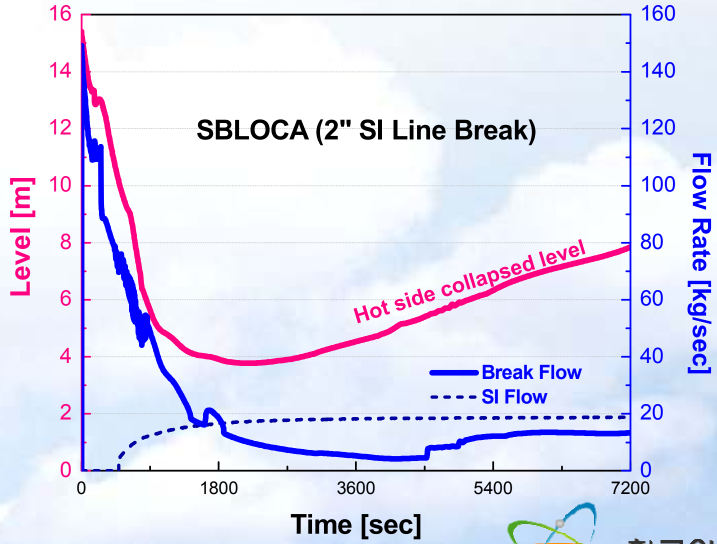
- Core Damage Frequency < 10^{-6}/RY
- Inherent Safety
  - No Large Break: Vessel Penetration < 2” (None from RPV Bottom)
  - Large Primary Coolant Inventory
  - No Return-to-Power by Excessive Cooling
  - Low Vessel Fluence
- Engineered Safety Features
  - Passive Residual Heat Removal System (4 Train)
    - Natural Circulation Cooling of SG from Secondary Side
  - Safety Injection System (4 Train)
    - Direct Vessel Injection from IRWST
  - Containment Spray Systems (2 Train)
  - Shutdown Cooling System (2 Train)

Accident Analysis



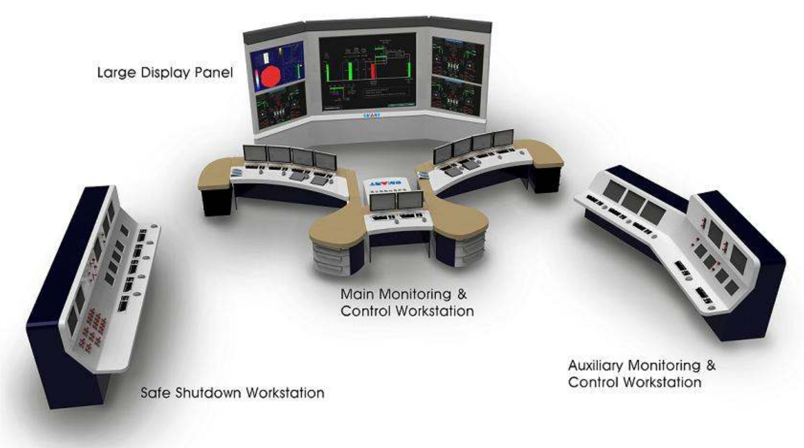


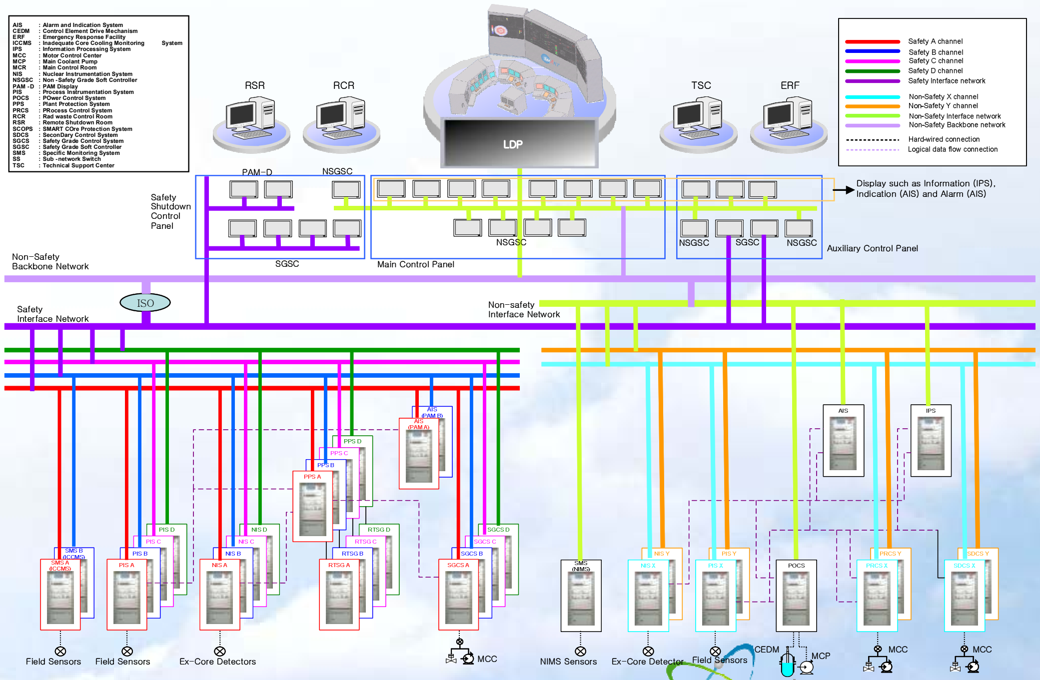




Digital MMIS

- **Fully Digitalized I&C System: DSP Platform**
  - **4 Channel Safety/Protection System and Communication**
  - **2 Channel Non-Safety System**
- **Advanced Human-Interface Control Room**
  - **Ecological Interface Design**
  - **Alarm Reduction**
  - **Elastic Tile Alarm**





Construction

❑ Footprint

- 300 x 300m for Electricity System
- 200 x 300m for Desalination System

❑ Construction Period

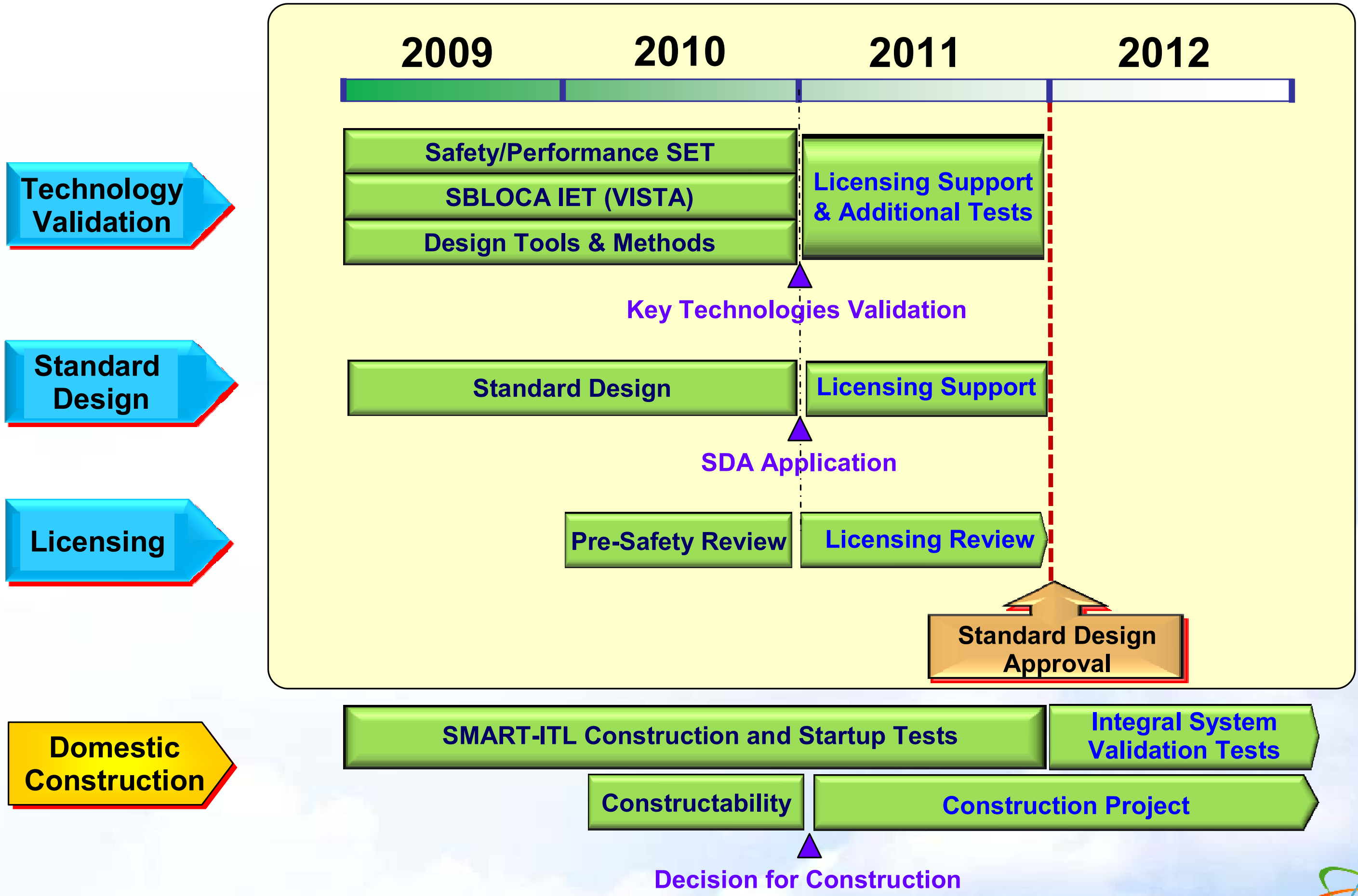
- 3 yrs

❑ Economics (as of '07)

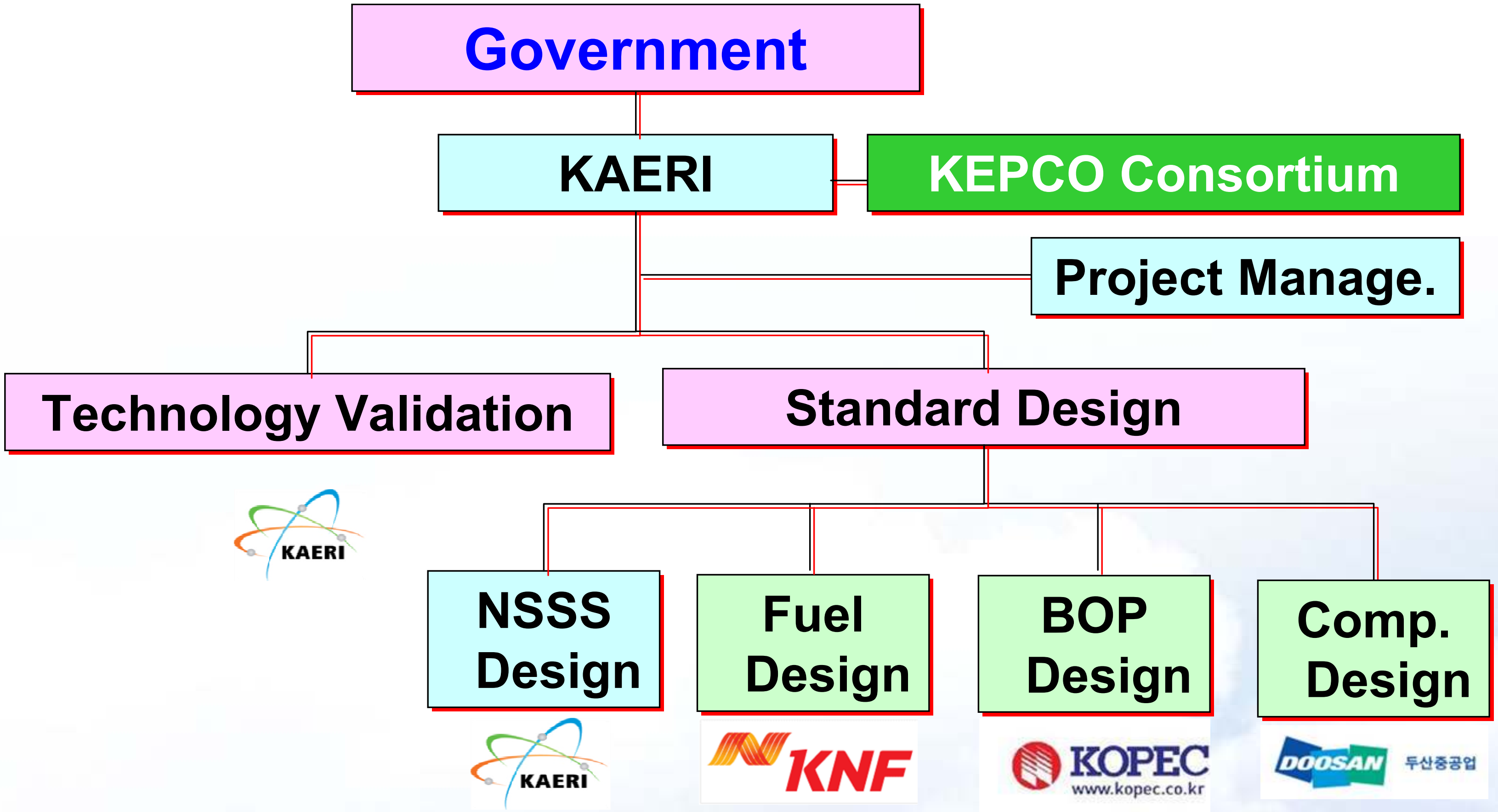
- Construction Cost: $5000/kWe
- O&M Cost: ~ 6.1¢/kWh (Lower than Hydro Power)

III. SMART Project

Standard Design Approval (SDA) by 2011
(256th & 257th Atomic Energy Commission)



Project Organization



- Technology Validation Project: $58M from Government
- Standard Design Project: $83M from KEPCO Consortium

- KEPCO Consortium was officially Inaugurated on June 14, 2010

KAERI

KEPCO Consortium

KAERI 한국원자력연구원 Korea Atomic Energy Research Institute

KEPCO
한국수력원자력(주) KOREA HYDRO & NUCLEAR POWER CO., LTD
KOPEC 한국전력기술주식회사
KNF
STX Heavy Industries
DSME DAEWOO SHIPBUILDING & MARINE ENGINEERING CO.,LTD.
DAEWOO E&C

POSCO
POSCO E&C 포스코건설
포스코 ICT
Daewoo Engineering
SEG SAMCHANG
일진 Energy

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Technology Validation Project

Technology Validation

Safety Tests

❑ Core SET
- Freon CHF
- Water CHF

❑ Safety SET
- Safety Injection
- Helical SG Heat Transfer
- Condensation HX Heat Transfer

❑ Integral Effect Tests
- VISTA SBLOCA
- SMART-ITL

❑ Digital MMIS Safety System
- Control Unit Platform
- Communication Switch
- Integral Safety System

Tools & Methods

❑ Code Devel/V&V
- Safety: TASS/SMR-S
- Core TH: MATRA-S
- Core Protec./Monitor.

❑ Design Methodology
- DNBR Analysis
- Accident Analysis (SBLOCA, LOFA, …)
- Integral Rx Dynamics

Performance Tests

❑ Fuel Assembly
- Out-of-Pile Mech./Hydr.

❑ RPV TH
- RPV Flow Distribution
- Flow Mixing Header Ass.
- Integral Steam PZR
- PZR Level Measurement

❑ Components
- RCP Hydrodynamics
- RPV Internals Dynamics
- SG Tube Irradiation
- Helical SG ISI
- In-core Instrumentation

❑ Digital MMIS Control Room
- MMI Human Interface
- Control Room FSDM

V&V

Technical Reports

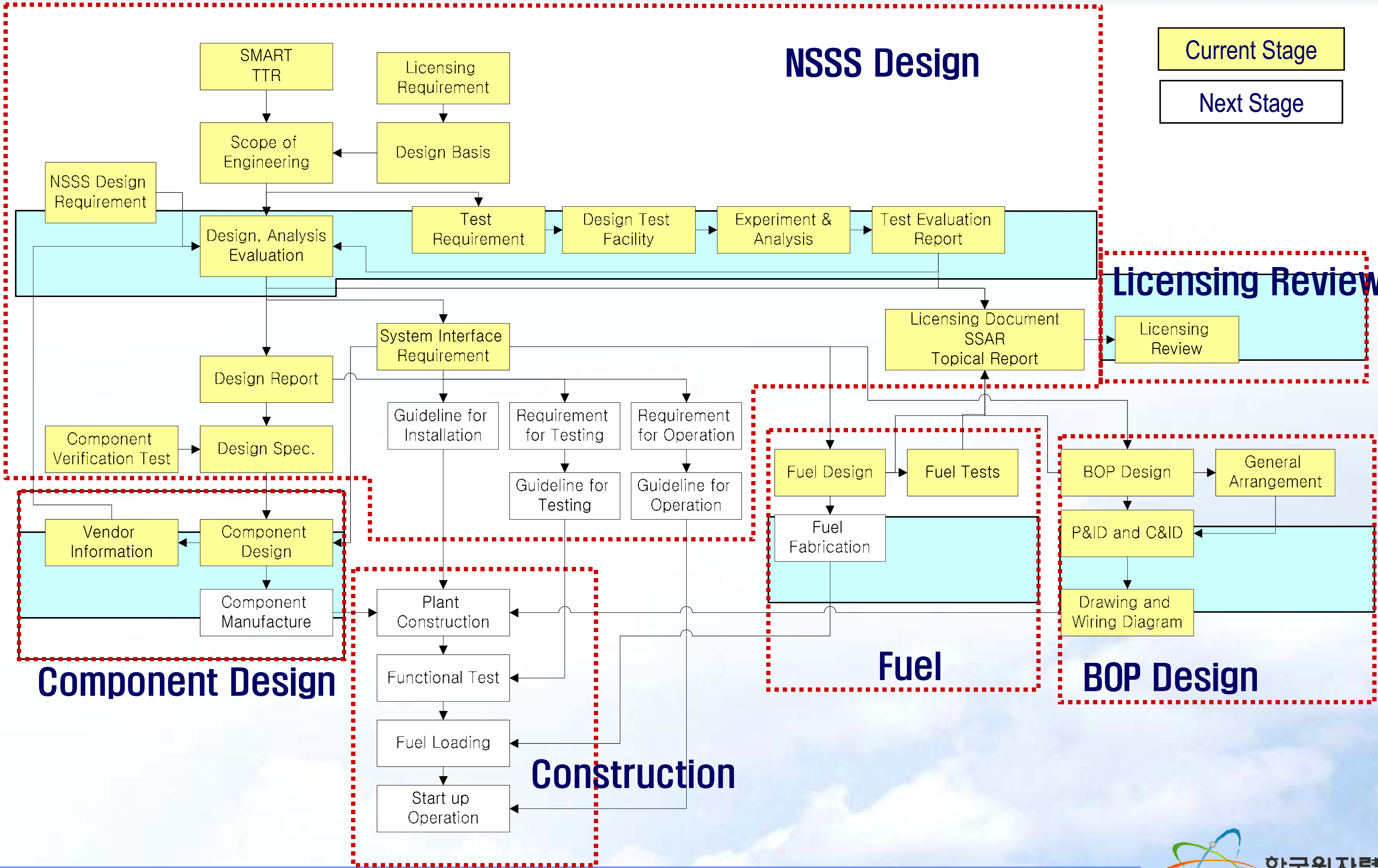
Standard Design

Design Data

Standard SAR

Standard Design Approval

Standard Design Project



Future Plans

❑ Licensing

- Licensing Authority: MEST technically supported by KINS
- Under Pre-Safety Review by KINS in 2010
- Standard Design Approval Application by the End of 2010
- Standard Design Approval by the End of 2011

❑ Domestic Construction

- KEPCO is setting up a Plan for Domestic Construction of a FOAK SMART by the End of 2010
- Decision for Domestic Construction by Government is expected in 2011, then, Conventional Two-step Licensing will follow

IV. Summary & Conclusions

- SMART is a Viable Option for Early Deployment in Small & Medium Reactor Market
  - Enhanced Safety & Operability by Advanced Design Features
  - Economic Feasibility
  - Flexible Applications for both Electricity and Heat
  - Low Risk by Proven & Fully Validated Technologies
  - KEPCO Consortium strengthens the SMART Viability

- Certified SMART Design will be available for Commercial Use in 2012 after the SMART Standard Design Approval

KAERI + KOPEC + KNF + DOOSAN

World-Class Technology Provider

KEPCO Consortium

Project Management
Marketing
Financing
Brand Power

SMART Team will make it SMART

Thank you
for your attention !

KAERI Korea Atomic Energy Research Institute